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(54) Abstract Title

Method for processing the production layer in a bottom hole area, packer therefor and method for securing a packer inside the bottom of a hole

(57) According to the invention, the method for processing the production layer in a bottom hole area (1) comprises the following steps: the liquid in the bottom hole area (1) is heated and clogging products are removed. According to the invention, the top of the bottom hole area (1) is sealed off before the liquid is heated and a chamber (6) is created in the bottom of the hole. The liquid in the bottom hole chamber (6) is cooled, and the chamber is unsealed once more before the clogging products are removed. The inventive packer (4) designed for processing the production layer in the bottom hole area (1) contains a body (10) (containing a radial joint containing sliding cheeks, a cup-type seal (15) and a drive) and a suspension (2). The lower butt (5) has the form of a concave surface of the second order. The method of fixing the packer (4) in a bottom hole (1) includes the following steps: the packer is lowered into the bottom hole (1) to a determined depth, the radial dimensions of the packer (4) are increased and the cup-type seal (15) is deformed radially. The packer is then subjected to a thermal action, whereby the temperature applied thereto is different from the temperature of the bottom hole liquid at the place where the packer is installed.

GB 2 372 526 A

This international application has entered the national phase early

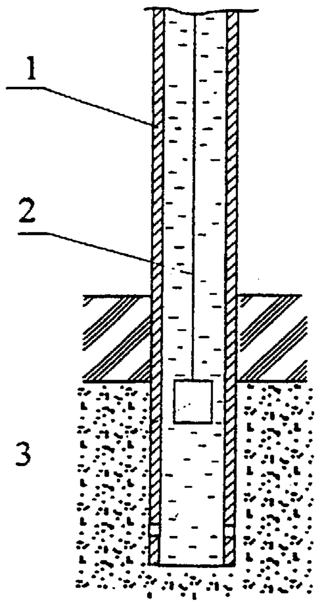

FIG. 1

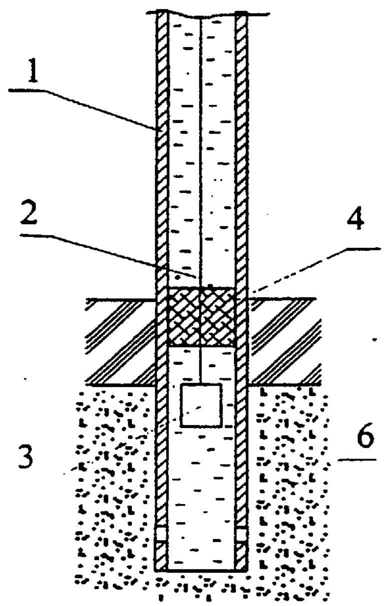

FIG. 2

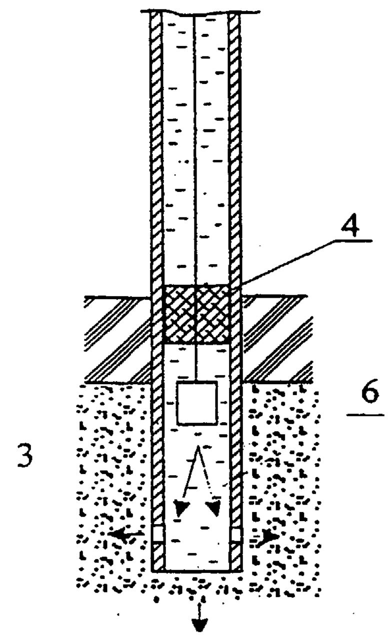

FIG. 3

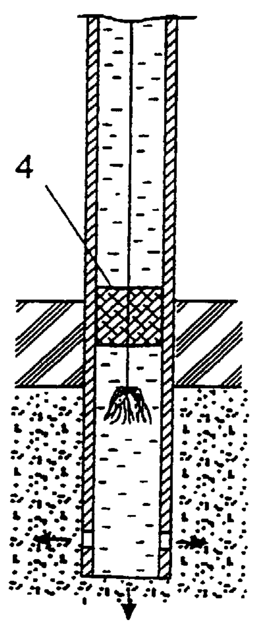

FIG. 4

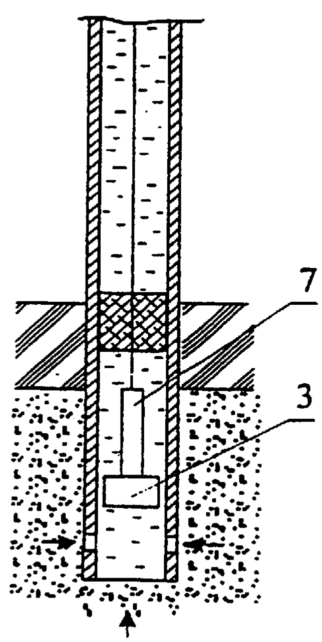

FIG. 5

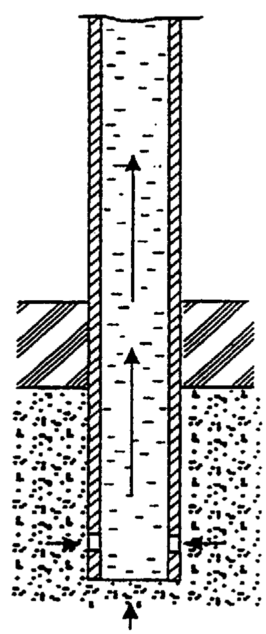

FIG. 6

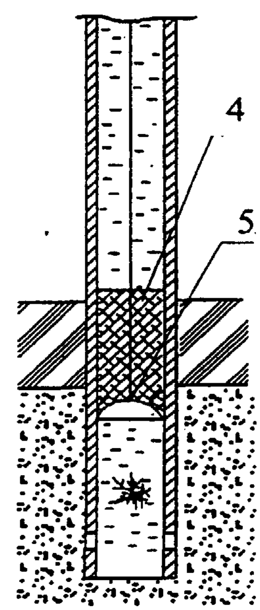

FIG. 7

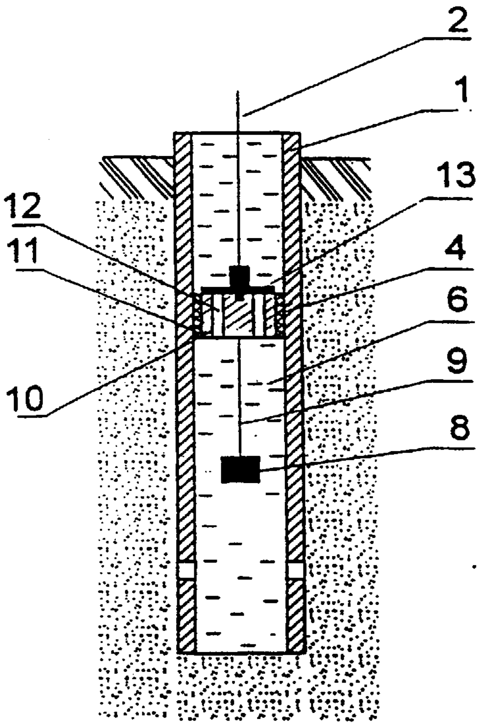

FIG. 8

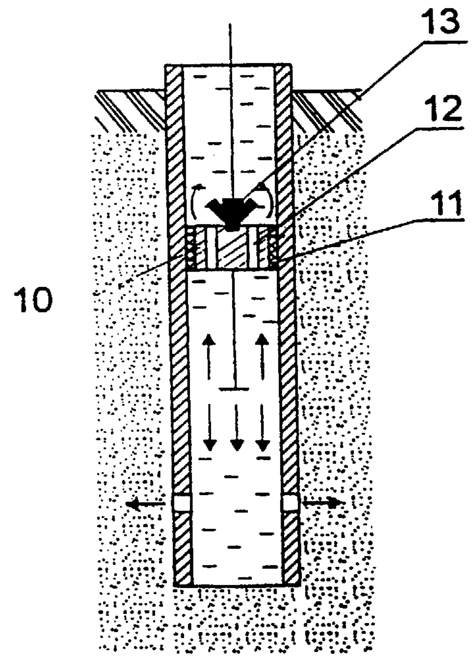

FIG. 9

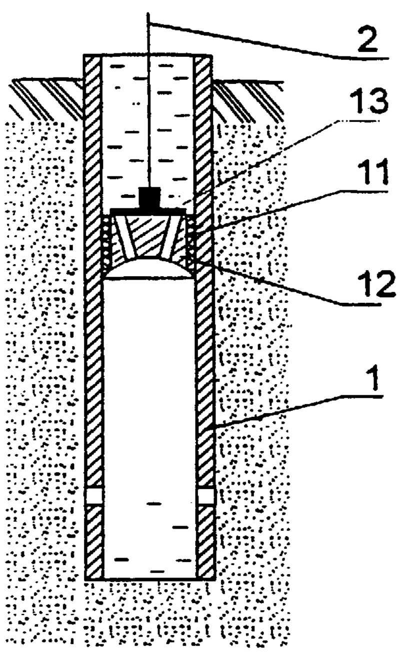

FIG. 10

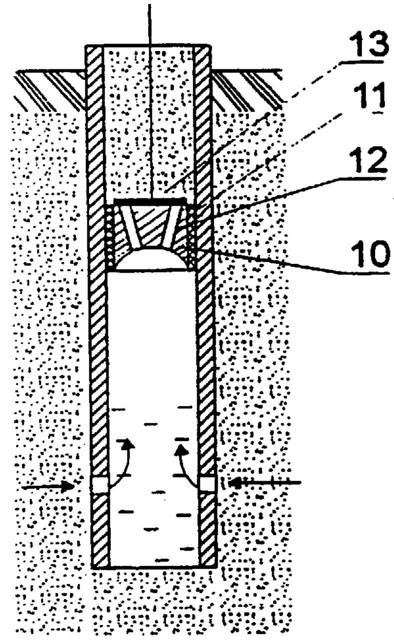

FIG. 11

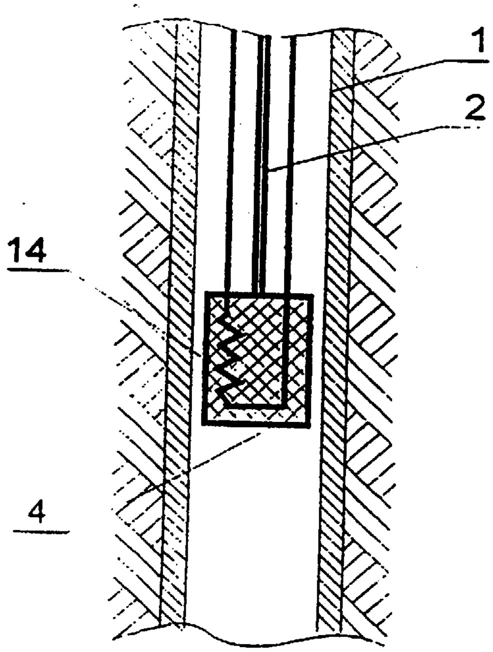

FIG. 12

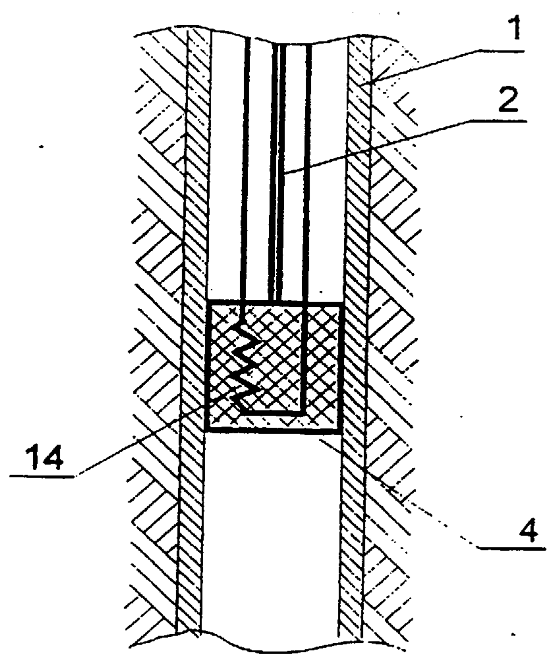

FIG. 13

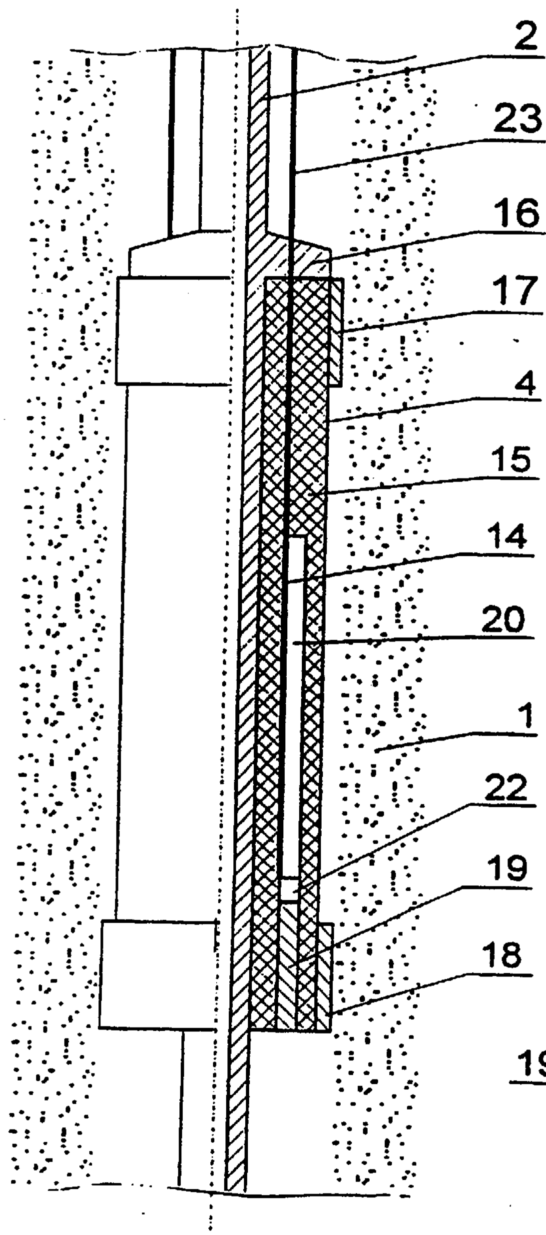

FIG. 14

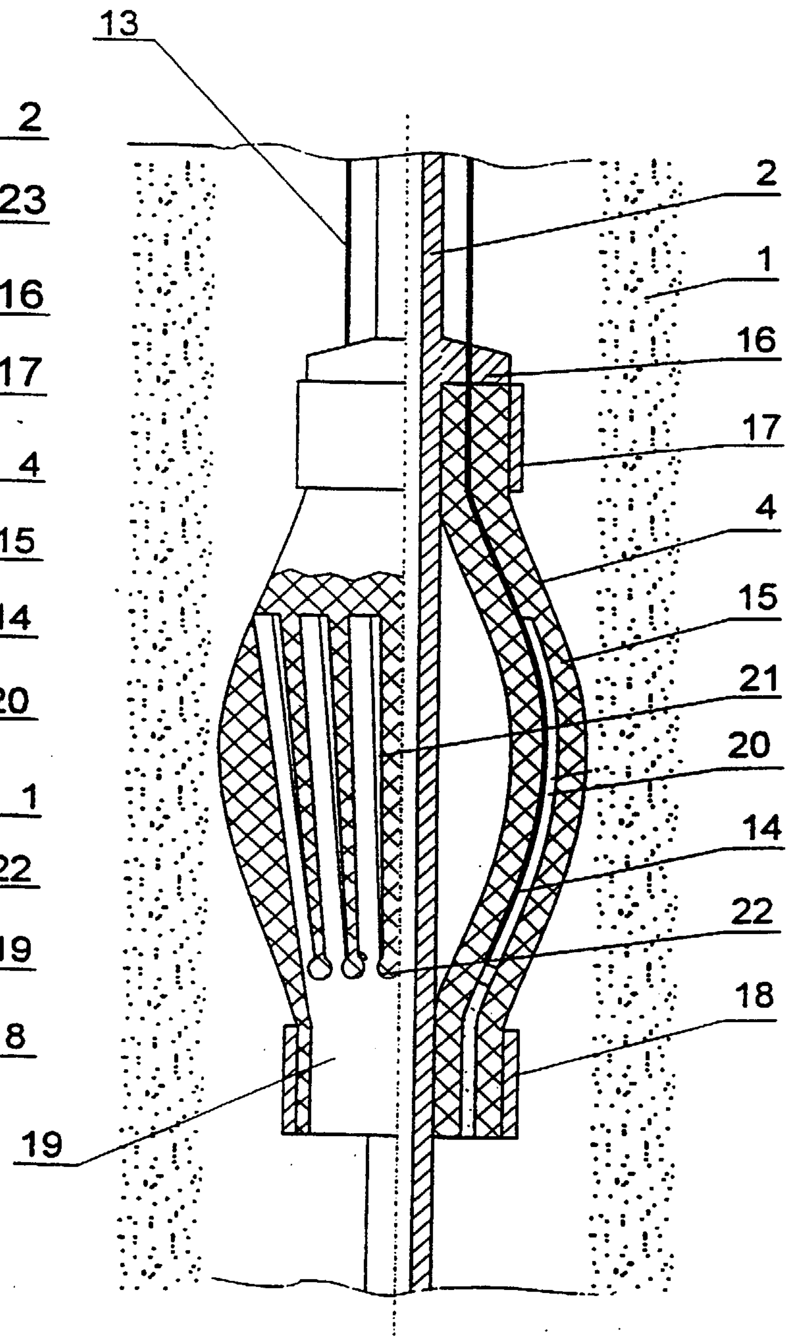

FIG. 15

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METHOD AND PACKER FOR PROCESSING A PRODUCTIVE FORMATION IN BOTTOM-HOLE ZONE OF A WELL, AND METHOD FOR FIXING A PACKER INSIDE A WELL

Field of the Invention

The proposed invention relates to the oil producing industry and has the purpose of increasing the productivity of a well by intensifying the flow of oil and increasing the oil recovery factor, and also serves for major repair of wells, for cutting-off water-encroached formations, etc.

Background Art

A method is known for electrically heating a bottom-hole zone (see, e.g., A.A. Popov. Impact action on bottom-hole zone. Moscow, "Nedra," 1990, pp. 36-38). This method consists in that the liquid in the bottom-hole zone is heated to about 100°C, which ensures a reduction of the viscosity of paraffin-base and high-viscosity crude oils of, for example, the Usinsky and Kharyachinsky fields. As a result the oil recovery from the wells is increased.

The main drawback of the foregoing method is that it is only possible to use it in a narrow field - during the production of high-viscosity and paraffin-base crude oils, when paraffins, resins and asphaltenes precipitate into the bottom-hole zone. Furthermore, the described method is complex in the practical realization thereof, since the electric heaters often break down because of the poor quality of the cable and the heating elements, which work in an aggressive medium.

A method for thermal treatment of the bottom-hole zone of an oil formation is also known according to USSR Inventor's Certificate No. 467173, class E 21 B 43/24, published in BI No. 14, 1975. This method consists in providing thermal treatment to the bottom-hole zone by pumping a heat carrier with high thermal conductivity into the formation. Granulated material, for example, metal powder, is used as the heat carrier. The granulometric composition of the metal powders is selected on the basis of considerations relating to their being pumped in and also to their capability of penetrating into cracks of the formation. A source of thermal-gas or thermal-gas-chemical action, the plane of the start of combustion of which is positioned below the lower perforations of the interval being processed by 5-15% of its length, is used as the slowly-burning source of thermal action, and after accumulating heat in the processed interval, movement of the

downhole technological equipment with the source of thermal-gas or thermal-gas-chemical action is carried out along the interval being processed, after which a technological delay is carried out to substitute the gaseous combustion products in the interval being processed with well liquid. The prepared suspensions do not penetrate into pore channels, but fill the formation cracks in the bottom-hole zone, which are present and open up in the process of pumping. After a system of cracks, filled with granulated metal powder, is created in the formation, an electrical heating device is lowered into the well and the bottom-hole zone is heated.

The method is also complex in realization, since actually it is a two-step method, i.e. at first hydraulic fracturing is effected, and then metal powders are pumped into the cracks. Its relatively low effectiveness is predetermined by the fact that in order for the metal powder to penetrate into the formed cracks, small forces, occurring as a result of the volumetric expansion during the heating of the bottom-hole liquid, are used, and therefore the heating spreads into the depth of the formation to only a small distance.

A method of fracturing a formation is known, the method comprising creating cracks by fracturing the formation with explosive gases and fixing the cracks by pumping a liquid with a solid agent, for example, silica sand, into the formation with a pump (see, for example, Yu.M. Zheltov. Deformation of rocks. Moscow, "Nedra," 1966).

A drawback of this method is the high amount of labor consumed and the cost, which is related to the use of pumps.

A method of fracturing a formation with explosive gases is also known from patent U.S. No. 3.422.760, class 102-21.6. This method comprises creating cracks by the pressure of gases which are produced during the combustion in the well of an explosive charge positioned opposite the productive formation. A drawback of this method is that the explosive gases are only partially used to create cracks in the bottom-hole zone, a part thereof (about 50%) goes up through the well, wherewith the cable to which the charge is suspended twists, and this predetermines the necessity for its subsequent extraction. This last step is rather complex, is often related to the necessity of cutting the cable and extracting separate pieces thereof with catchers. Sometimes, it is not possible to extract all the pieces of the cut cable and the well has to be abandoned.

A method of processing the zone of a productive formation in the region of the bottom with the use of implosion is also known (see, for example. A.A. Popov. Impact actions on bottom-hole zone. Moscow, "Nedra," 1990, pp. 35-36). The substance of this method is that a hollow vessel with a membrane is arranged on a tubing string opposite the

interval of the formation being processed. Then this membrane is fractured, as a result of which rarefaction is created in the bottom hole. Due to the occurrence of depression of the pressure, the formation liquid enters the well at high speed. The intensive movement of the formation liquid into the well promotes the cleansing of the part of the formation being filtered of deposits.

An analysis of the available results of processing bottom-hole zones with the use of implosions at the Zapadno-Tebuksk, Nizhneomrinsky and Izhma-Omrinsky oil fields has shown that this method has limited use in respect to mining and geological conditions. It is of low effectiveness at high permeability of the bottom-hole zone, since the speed of the flow of formation liquid from the productive formation into the well is low because of the large size of the pores and cracks in the bottom-hole zone.

Furthermore, there were cases where the use of implosions did not provide the desired result because the membranes, produced from grey iron SSH15-32, fractured before they were supposed to. This reduces the range of use of the method with implosions and its effectiveness, and wherewith, a positive result is not achieved in all cases when this method is used.

The analog most similar to the proposed method in respect to technical essence and attained effect is the method for processing the bottom-hole zone according to patent RF No. 2087693, class E 21 B 43/25, published in BI No. 23, 1997. This latter method comprises lowering downhole technological equipment with a charge of a slowly burning source of thermal action, burning the latter in an interval being processed, carrying out a technological delay to accumulate heat in the interval being processed, providing depression action and removing a part of the well liquid with clogging elements which entered it from the bottom-hole zone during the depression action. Wherein, a slowly-burning source of thermal action is used, the plane of the beginning of combustion of which is positioned below the lower perforations of the internal being processed by 5-10% of its length, and after accumulating heat in the interval being processed, the downhole technological equipment with the source of thermal-gas-chemical action is moved along the interval being processed, after which there is a technological delay to substitute gaseous combustion products in the interval being processed with well liquid.

Drawbacks of this method are: a) the difficulty of implementation, related to movement of the equipment along the interval being processed; b) the length of the process, related to movement of the equipment and the technological delays in order to replace the gaseous combustion products in the interval being processed with well liquid;

c) small distances from the well walls on which the high-temperature zone acts (it is because of this reason in particular that it is necessary to move the equipment with the source of thermal action along the well). All these drawbacks reduce the effectiveness of use of this method.

A packer is known in accordance with USSR Inventor's Certificate No. 1099047, class E 21 B 33/12, published in BI No. 23, 1984. This packer comprises a hollow body with radial channels, on which body a seal element with a cavity for its drive is mounted, a shaft arranged in the body with the possibility for axial movement and coupled to a string, the shaft being hollow, sealed in the lower part, with two rows of radial channels to couple the intratube space accordingly with the annulus above-packer space and the cavity of the seal element drive. Wherein the packer is provided with a housing with radial channels, which is mounted above the seal element and forms with the body a chamber in which a spring-loaded choke bean is mounted, and the annulus above-packer space is coupled to the intratube space via the channel of the choke bean.

Drawbacks of the known packer are the complexity of its structure and, in view of this, low operational reliability, since clogging of the channel "A" of the hydraulic resistance and the openings, communicating its inner cavity with the upper, and the upper and lower chambers, with particles found in the well liquid, is not eliminated. The packer under consideration seals the cross section of the well, preventing movement of the flow in any direction. A packer of such a construction cannot be used in the case where it is necessary to provide for flow of the well liquid in one direction only.

An interval packer is known according to USSR Inventor's Certificate No. 643625, class E 21 B 33/12, published in BI No. 3, 1979. This packer comprises upper and lower packers with shafts made with radial channels, a body with windows, an anchor, a valve device, case and catch, wherein the shaft of the lower packer is rigidly connected to the case, and the catch is mounted at the end of the shaft of the upper packer with the possibility for interaction with the case, wherein in the lower part of the shaft of the lower packer a branch pipe is rigidly connected thereto, the branch pipe forming with the shaft an annular cavity, and a piston is mounted under a sealing element, the piston forming with the shaft a chamber communicating with the annular cavity, and during packing - with the intrapacker space. The construction of the packer is designed to cut off the flow of liquid and it cannot be used to provide passage of the flow of well liquid in one direction only.

A packer according to USSR Inventor's Certificate No. 304345, class E 21 B 33/12, published in BI No. 17, 1971, is also known. This packer comprises a body with radial

channels, sealing elements with slips, a housing and fixing unit with spring-loaded slips interacting with pushers and a toothed surface of a branch pipe. A piston, rigidly connected to pushers, is positioned concentrically between the body and the housing, and the under-piston cavity communicates with an intrapipe space.

A drawback of the known packer is the low reliability of its operation because of the possible clogging of channels "a" and "b" and cavities "A" and "B" with particles which are in the well liquid. Furthermore, the cross section of the central channel of the packer is sharply reduced because of the concentrically positioned body, annular piston and housing.

A well fixing apparatus according to USSR Inventor's Certificate No. 1122817, class E 21 B 47/00, published in BI. No. 41, 1984, is also known. This apparatus comprises a body, a cable, a bushing, a stopping device, a tightening mechanism coupled to a spacer element provided with a parachute of elastic material stretched on a frame of levers hinge-connected to the bushing, and a resilient element, an additional spring, additional supports, a stopping bushing with inner supports and with a ring-catch, lower levers, wherein the additional spring is arranged inside the stopping bushing mounted in the lower part of the body, spring-loading the bushing relative to the body, and interacts with the tightening mechanism, and the additional supports are mounted on the lower levers, hinge connected to the resilient element. The lower end face thereof is made in the form of a cone.

A drawback of the fixing apparatus being considered is the ineffectiveness of its use during an explosion, since the gases produced thereby will promote unsealing of the well.

The analog most similar in respect to technical essence and attained effect is the hydraulic packer for a formation tester according to USSR Inventor's Certificate No. 571581, class E 21 B 33/12, published in BI No. 33, 1977. This packer comprises a rod, a hydraulic pump and an elastic cup with a springy support made of inner and outer rows of plates shifted relative to one another. Wherewith, the inner plates are provided with end pieces which are placed in the elastic cup and rigidly connected to the plates of the outer row. The lower surface of the packer is made flat, passing into a conical surface, then again into a flat and conical, which form with the wall of the well a wedge "pocket."

A drawback of the packer under consideration is that its use is not possible in order to provide flow of the well liquid in one direction only, since it completely seals the flow cross section of the well. Furthermore, a drawback of the packer is its low reliability,

this being related to the possibility of channel "a" and the inner cavity of the elastic cup being clogged with particles which are in the well liquid.

A method for fixing a packer in a well is known, this method being realized in the construction of the packer according to USSR Inventor's Certificate No. 252244, class E 21 B, published in BI No. 29, 1969, and consisting in that the sealing elements of the packer are unwedged, moving one part thereof relative to another, wherein the tapered elements of the packer, which have tapered surfaces, are moved (in the longitudinal section two neighboring elements have an inclined surface, and each element is made in the form of a triangle, wherein one of the bases of neighboring elements faces the wall of the well, the other faces the longitudinal axis thereof). In order to extract the packer it is pulled upwards, thereby cutting off the pins and thus reducing its cross section.

A drawback of this method is the difficulty of extracting a packer of such a construction because of the large diametrical dimensions, since tapered sections are used which move one on top of another, as a result of which the packer occupies greater space in the cross section. During the unwedging it is not possible to substantially reduce its cross section in order to reliably extract it from the well.

A method for fixing a packer in a well is also known, this method being realized in the hydraulic packer according to USSR Inventor's Certificate No. 571581, class E 21 B 33/12, published in BI No. 33, 1977, and consisting in that an elastic cup is spread apart in a radial direction by applying drilling fluid under pressure into the inner cavity of the elastic cup. A piston and hydraulic pump are used to create pressure. In order to extract the packer, the pressure is turned off and by moving the piston to the upper position the elastic cup is returned to its initial position by springs especially serving this purpose.

A drawback of the described method is the necessity of using two drives to fix the packer to the wall of the well and to separate it therefrom, and this makes the construction of the packer and control of its operation more complex.

A method for fixing a packer, realized in a packing device according to USSR Inventor's Certificate No. 898043, class E 21 B 33/12, published in BI No. 2, 1982, is known. This method comprises changing the radial dimension of a sealing element of the packing device by mechanical axial action on it, wherewith this action is carried out in two steps, in particular: at first the lower part of the packing device is set in the bottom hole of the well, moving one of its parts relative to another in an axial direction, and then contraction is created by hydraulic pressure.

A drawback of the known method is that it is not possible to mount the packing device high above the well bottom. Furthermore, the use of two drives for fixing and separating predetermines complexity of the construction of the packing device and complexity of its control.

The analog most similar in respect to technical essence and attained effect is the method for fixing a packer in a well, which is realized in the packer according to USSR Inventor's Certificate No. 304345, class E 21 B 33/12, published in BI No. 17, 1971, and consists in radial deformation of an annular packer seal as a result of its axial compression by the hydraulic pressure of liquid pumped into the well.

A drawback of the known method is that it does not ensure reliability of operation of the packer, this being related to the necessity for a constant supply of well liquid under pressure, which finally results in clogging of the working chamber of the packer, which via the moving piston supplies the hydraulic pressure of the liquid to the sealing elements of the packer.

Disclosure of the Invention

The technical object of the proposed invention is to enhance the effectiveness of oil inflow, and consequently, enhance the productivity of the well by removing the clogging products from the bottom-hole zone, and to simplify the technology of processing the bottom-hole zone by removing the clogging products from the bottom-hole zone of the well in one step and to eliminate destruction of the packer suspension means. Furthermore, the construction of the packer is simplified and the reliability of its fixation in the well is enhanced by temperature action and additional tightness between the surfaces of the packer and the well.

This object is achieved in a method for processing the productive formation in a bottom-hole zone of a well, comprising heating liquid in the bottom-hole zone and removing clogging products from the bottom-hole zone, in that in accordance with the technical solution, prior to heating the liquid, the bottom-hole zone of the well is sealed in the upper part, forming thereby a bottom-hole chamber, and after heating, the liquid is cooled in the volume of the bottom-hole chamber and then this chamber is unsealed prior to removing the clogging products therefrom.

These steps and their sequence ensure a liquid flow at first in the direction of the formation due to volumetric expansion of the liquid in the bottom-hole chamber, and then in the reverse direction from the formation due to depression, which ensures the

simultaneous expansion of cracks in the bottom-hole zone as a result of the produced flow, and consequently, pressure of the liquid, and also reduction of the viscosity of the oil and removal of asphalt-resin-paraffin deposits by temperature action (the known effect of temperature action). The reverse flow of liquid from the formation into the bottom-hole chamber promotes purification of the filtered part of the formation of deposits and in certain cases results in breakage of the rock in the bottom-hole zone of the well and the formation of additional cracks there. This, finally, enhances the productivity of the well and simplifies technology, since cases of twisting the cable in the well because of the presence of the parker are eliminated, and this means that steps in respect to cutting it and extracting separate pieces of the cable with catchers are eliminated.

It is advisable that the liquid in the bottom-hole chamber be heated to a temperature above the boiling point of one of the light oil fractions, e.g., gasoline.

Such a step ensures the transition of light oil fractions into vapors. (The boiling point is 80-96°C. Here and below consideration is given to normal pressure in view of the fact that the pressure in the liquid in the bottom-hole zone depends on the depth of the well. In view of this, the boiling point of water and the fractions increases, remaining however different one from the other, i.e. for a concrete well, their boiling points should be calculated in accordance with the weight of the column of liquid in the well.) The liquid in the bottom-hole chamber increases its volume to a greater degree and this is promoted by the vapor into which one of the components of the light fractions of oil has passed. As a result, the pressure in the bottom-hole chamber is sharply increased and, as a consequence thereof, the effectiveness of the oil inflow is increased, since at higher pressure its action is effected at a greater distance from the well and the depression effect will also be large.

It is advisable that the liquid in the bottom-hole chamber be heated to a temperature above the boiling point of water.

Such a step makes it possible to enhance the effectiveness of the process of processing the bottom-hole zone of the well, since the boiling point of water is above the boiling point of the light oil fractions (respectively 100°C and 80-96°C at normal pressure). Therefore, there is a transition of water and the light oil fractions into vapor, and, consequently, the partial pressure of the liquid components in the bottom-hole chamber which pass into vapor will be added up and the resultant pressure becomes greater than the partial pressure of one of the liquid components which have passed into vapor.

It is advisable that the liquid in the bottom-hole zone be heated to a temperature above the boiling point of one of the heavy oil fractions, e.g., oils. This step even more enhances the effectiveness of the proposed method, since a large number of the liquid components in the bottom-hole chamber pass into vapor (the boiling point of oils is 460-500°C at normal pressure), consequently, the total pressure in the bottom-hole chamber increases in accordance with the Dalton Law. The effectiveness of the action of pressure in the bottom-hole chamber also increases, that is it will act on the particles deposited in the pores of the bottom-hole zone at a greater distance from the walls of the well. The permeability of the bottom-hole zone of the productive formation is enhanced by the simultaneous action of the pressure and temperature created in the bottom-hole chamber.

It is advisable that the liquid in the bottom-hole chamber be heated instantly, e.g., by an explosion. The effects described above will be manifested to an even greater degree, since the produced vapors which are in the bottom-hole chamber do not have time to partially fall into the liquid and into the productive formation, which is observed during slow heating, as a result of which increased pressure will be in the bottom-hole chamber, and consequently, the action of pressure will occur at a greater distance from the well.

It is advisable that cooling the liquid within the volume of the bottom-hole zone of the well be carried out in a forced manner with the use of special means, for example, thermocouples.

Such an operation intensifies the flow of liquid from the productive formation into the well, which makes it possible to first remove the clogging products from the bottom-hole zone of the well and then to increase the oil production rate.

It is advisable that after the formation of the bottom-hole chamber, the column of well liquid therein be divided into two parts, one of which directed to the bottom-hole zone of the well, the other removed through the packer, and that movement of the well liquid through the packer in the opposite direction be closed.

These operations and their sequence make it possible to carry out hydraulic fracturing in the bottom-hole zone of the well and simultaneously to create depression of the pressure in the bottom-hole chamber by removing well liquid from that chamber, which ensures a back flow of liquid from the formation into the well after the hydraulic fracturing, and this makes it possible to wash the cracks and pores in the bottom-hole zone of the well, thereby removing the clogging products. Finally, these operations make it possible to increase the inflow of formation liquid, which increases the effectiveness of oil inflow, and consequently to increase the productivity of operating the well.

It is advisable after removal of a part of the column of well liquid from the bottom-hole chamber through the packer to reduce the pressure in the upper part thereof and simultaneously to fill the bottom-hole chamber with formation liquid.

This makes it possible to increase the intensity of the inflow of formation liquid into the well, which enhances the washing of the cracks and pores in the bottom-hole zone of the well, and, consequently, improves the removal of clogging products.

In a packer for processing the productive formation in the bottom-hole zone of a well, comprising a body with a means for radial compaction in the form of sliding cheeks, a cup-type seal and a drive, and a suspension means, in accordance with the technical solution, the lower end face is made in the form of a concave surface of the second order.

Such a construction of the packer is less subject to the negative actions of an explosion, in particular, the absence of "pockets" eliminates unsealing of the packer (moreover, improves the sealing), and, being a reflector, directs the explosive wave along the axis of the well in the direction of the productive formation, which improves the effectiveness of processing the productive formation in the bottom-hole zone of the well.

It is advisable that the concave surface of the second order in the packer be made hemispherical.

Such a construction of the packer is the simplest in production and during an explosion, by directing the explosive wave along the longitudinal axis of the well, ensures its self-compaction.

It is advisable that the concave surface of the second order in the packer be made paraboloidal.

Such a construction of the packer enhances the effectiveness of its self-compaction and the directivity of the explosive wave along the longitudinal axis of the well, since the lower end face surface of the packer at the wall of the well has great length and more gradually passes into a cylindrical surface.

It is advisable in these cases that the packer be made with at least one channel connecting its end faces and be provided with a back-pressure valve, eliminating movement of the well liquid in the direction to the bottom-hole chamber from the above-packer space of the well.

Such a construction of the packer provides for realization of the proposed method for processing the productive formation in the bottom-hole zone of a well, i.e., the effective removal of a part of the well liquid from the bottom-hole chamber with subsequent depression of the pressure therein by removal of the clogging products.

It is advisable that the packer be provided with a temperature-action element. Such a construction of the packer provides for temperature action (heating or cooling) on its elements, which makes it possible to increase or reduce the diametral size of the packer cup-type seal, ensuring fixation of the packer to the wall of the well (or its separation therefrom).

It is advisable that the temperature-action element of the packer be made in the form of a pyrotechnic cartridge. Such a construction of the packer provides one-time heating of its structural elements, which predetermines the possibility for minimization of the energy necessary to heat them.

It is advisable that the temperature-action element of the packer be made in the form of an electric spiral connected to a power supply. Such a construction of the packer is as simple to produce as possible and makes it possible to heat the elements of the packer construction a multiple number of times.

It is advisable that the temperature-action element of the packer be made in the form of a cooling thermocouple. Such a construction of the packer eliminates the necessity for a constant supply of energy during its fixation to the wall of the well (the energy is used only during its extraction from the well or during its installation in the well).

It is also advisable that the sliding cheeks of the packer be made of a material with shape memory. Such a construction increases the reliability of packer operation, since it ensures reliability of its fixation, independent of the diameter of the well and the cup-shaped packer seal, which is made with a certain exactness and may change its size under the effect of wear. Furthermore, the diameter of the well has a different magnitude at different points of the depth.

In this case it is advisable that the sliding cheeks of the packer be made in the form of a cylinder with longitudinal slots, ending with openings, wherewith the longitudinal parts of the cylinder between the slots be made in the form of lobes. Such a packer, having a simple construction, provides reliable fixation to the wall of a well and separation therefrom, and also free extraction from the well.

In a method for fixing the packer in a well, comprising lowering it into the well to the required depth, increasing the diametral size of the packer and deforming its cup-type seal in the radial direction, in accordance with the technical solution, the packer is subjected to temperature action, different from the temperature of the well liquid at the point of installation of the packer. Such a combination of steps enhances the reliability of fixing the packer to the wall of the well and simultaneously makes it possible to simplify

its construction, since the movable parts are removed therefrom and there is one drive to fix the packer to the wall of the well and to separate it therefrom.

It is advisable that the temperature action on the packer be carried out by increasing the temperature to a temperature above the temperature of the well liquid in the place where the packer is installed after it has been lowered to the required depth. This makes it possible to control the process of fixing the packer in the well independent of its depth (the temperature of the well liquid depends on the depth of the well). Furthermore, the possibility appears for enhancing the reliability of operation of the packers of known constructions by use of additional tightness created on the contacting surfaces of the cup-type seal and the well when the packer is equipped with a heating element.

It is advisable that the temperature action on the packer be carried by reducing the temperature to a temperature below the temperature of the well liquid at the place where the packer is installed prior to its being lowered to the required depth. The introduction of such a step makes it possible to provide fixation of the packer for a lengthy period of time without consumption of additional energy, since the fixation is accomplished by the temperature of the well liquid.

It is advisable after the temperature action on the packer at the place of its installation in the well at the required depth to carry out its temperature relief. The introduction of such a step enhances the reliability of extracting the packer from the well, since its diametral size is reduced, which ensures its free extraction from the well.

Brief Description of the Drawings

The substance of the proposed method for processing a productive formation in the bottom-hole zone of a well, a packer for carrying out the method and a method for fixing the packer in the well is explained by an example of their use and by drawings.

The presented drawings show the following.

Fig. 1 shows the steps for installing a heating element in a well;

Fig. 2 shows sealing of the upper part of the bottom-hole zone of a well;

Fig. 3 shows heating the liquid in the bottom-hole chamber and creating a flow of liquid moving toward the formation;

Fig. 4 shows an explosion in the bottom-hole chamber;

Fig. 5 shows the step of cooling the liquid in the bottom-hole chamber and forming a reverse flow of liquid as a result of depression;

Fig. 6 shows unsealing of the well;

Fig. 7 shows a packer arranged in the well;

Fig. 8 shows the installation of a packer in the well and the formation of a bottom-hole chamber;

Fig. 9 shows the division of a column of well liquid in the bottom-hole chamber and the removal of well liquid therefrom towards the productive formation and through the packer;

Fig. 10 shows the bottom-hole chamber purified of well liquid and depression of the pressure created;

Fig. 11 shows the filling of the bottom-hole chamber with formation liquid;

Fig. 12 shows the step of installing the packer in a casing;

Fig. 13 shows the step of thermal action on the packer (heating) and its fixation in the casing;

Fig. 14 shows a packer made of a material with a shape memory and with a cooling thermocouple installed in the well;

Fig. 15 shows a packer made of a material with a shape memory, fixed in a well.

Best Variant of Carrying Out the Invention

Realization of the proposed methods and packer is carried out in the following sequence.

Using a suspension means (cable or pipe) 2, a heating element 3 (Fig. 1) is lowered into the bottom-hole zone of a well (casing) 1. The heating element 3 may be of any construction and its principle of action may be based on any physical or chemical effect. Thus, for example, a slowly burning source of thermal-gas-chemical action in the form of a EPJU-98-850 pyrotechnic charge with the following characteristics may be used: length - 850 mm, diameter - 98 mm, weight - 7.5 kg; components - fuel 54%, oxidant 40%, technological additives 6%; density - 1.83 g/cm^3; combustion heat - 2000-2200 kcal/kg; combustion speed - 20 mm/s; time of burning - 42.5 s; volume of gaseous products - 600 l/kg; composition of combustion products: Cl_2, H_2O, H_2, MeO: combustion temperature - 2500°C: ignition temperature - 500-700°C; current for ignition of pyrotechnic charge - 3-4 A. When such a source is used, all the components of the well liquid pass into a vapor state as a result of heating. The further from the heating element, the lower the temperature, and consequently, there will be a zone where water and light fractions pass into vapor, then there will be a zone where only the light fractions of oil pass

into vapor, and finally, there will be a zone where all the liquid in the well 1 is heated and its volumetric expansion takes place.

An example is provided wherein the liquid is heated to a temperature higher than the boiling point of the heavy fractions. However, the heating temperature may be reduced to, for example, 100°C. In this case, there will not be a zone in which the heavy oil fractions pass into a vapor state. However, the other zones remain.

The next step is sealing the well 1 in the upper part above the point where the heating element 3 is positioned. In order to do this a packer 4 of any construction is used (Figs. 2-5, 7). In the case of instant heating (during an explosion) of the liquid in the bottom-hole zone of the well 1, it is advisable that the lower end face 5 of the packer 4 (Fig. 7) be made in the form of a concave surface of the second order. Thus, a bottom-hole chamber 6 is formed in the bottom-hole zone of the well 1, the upper part of chamber 6 being sealed.

Then heating the liquid in the bottom-hole chamber 6 is begun. Volumetric expansion of the liquid in the bottom-hole chamber 6 takes place as a result of an increase of the temperature, and this predetermines the formation of a flow of liquid towards the bottom hole of the well 1, and consequently, toward the productive formation (Fig. 3). The higher the temperature to which the liquid in the bottom-hole chamber 6 is heated, the more intensive will be its flow in the direction toward the productive formation. After heating the liquid in the bottom-hole chamber 6 stops, it is cooled in that chamber 6, which reduces its volume (Fig. 5), as a result of which a reverse flow of liquid is formed from the productive formation to the chamber 6. The intensity of the reverse flow will depend on the speed of cooling the liquid in the bottom-hole chamber 6.

The speed of the reverse flow of liquid will be minimum in the case where cooling is carried out in a natural manner, this making the step simple to perform, since no equipment is needed. However, this step may be accomplished faster by carrying out forced cooling of the liquid in the bottom-hole chamber 6. In order to do this a special means, for example a cooler 7, is preliminarily placed in the bottom-hole chamber 6 below the packer 4 (Fig. 5). It is advisable that the cooler 7 and the heating element 3 be secured to the packer 4 from below and lowered simultaneously into the well 1. The cooler 7 may operate in accordance with any principle of action: mechanical, when cold water is fed from the surface of the well 1; electrical, when thermocouples are used for cooling; or chemical, using expanding gases. The more intense the cooling, the more intense the reverse flow of the liquid, and, consequently, the better the purification of the

cracks and pores in the bottom-hole zone (filtration is improved). As a result, the inflow of oil from the productive formation into the well 1 is increased. The selection of the principle of cooling and corresponding special means will be determined by an economical approach and by the degree of perfection of one or another method or set of equipment.

If the first step--heating the liquid in the bottom-hole chamber 6--results in an improvement of the permeability of the bottom-hole zone, since clogging the pores and cracks of the bottom-hole zone is reduced in view of the heating and melting of the paraffin, resin and asphaltenes deposited in the cracks and pores, the step relating to cooling the liquid in the bottom-hole chamber 6 creates rarefaction in the bottom-hole zone, as a result of which intensive movement of the liquid from the productive formation to the well 1 is observed, which promotes purification of the part of the productive formation being filtered of deposits of particles, paraffins, resins, etc., and in some cases results in destruction of the rock of the bottom-hole zone of the productive formation and formation of new cracks there. Cases are known when after processing the bottom-hole zone with a reverse flow of liquid, using implosion, the inflow of oil in oil producing wells 1 increases several times. Sometimes wells 1, operated according to a mechanized method, turn into spouting wells.

The next step is unsealing the bottom-hole zone of the well 1 (Fig. 6), that is removal of the packer 4, after which the oil producing well 1 may be exploited. The clogging products are removed from the bottom-hole zone of the well 1 after the latter is unsealed. This step is carried out simultaneously with the oil production.

When the liquid in the bottom-hole chamber 6 is heated to a temperature of 80-96°C (here and below consideration is given to temperature at normal pressure, since the pressure of the liquid in the bottom-hole zones in wells 1 is different and depends on the depth of the well 1, which changes from 800 to 4000 m depending on the deposit), the light fractions of oil (gasoline, benzene, etc.) boil, water boils at a temperature of 100°C, the heavy oil fractions boil at temperatures of 460-500°C. In the bottom-hole zone, the boiling point of water and intermediate oil fractions increases depending on the pressure of the vertical column of the liquid in the well 1, remaining different from each other.

If the light fractions of oil are heated to the boiling point, the partial pressure in the bottom-hole chamber 6 is created only by vapors of the light fractions of oil. If the temperature is increased, partial pressure occurs from the vapors of light fractions, water and heavy fractions of oil. Accordingly, the total pressure of the gases, which do not

interact chemically with each other, is equal to the sum of the partial pressures of these gases (Dalton Law).

In order to determine the optimum temperature for heating the liquid in the bottom-hole chamber 6 it is necessary to know the composition of the liquid in the well 1. If the water encroachment of the latter is strong, then the heating may be limited to 100°C, taking into account the pressure of the liquid in the well 1 (taking the depth of the well into account). If there are many light fractions in the oil, the heating temperature may be reduced, and to the contrary, where there are a large number of heavy (viscous) fractions in the oil, it is advisable that the temperature be raised to the boiling point of those latter fractions. At any heating temperature, the liquid, which has not passed into vapor will increase in volume and thus promote the creation of a flow from the bottom-hole chamber 6 toward the productive formation. However, this component will be less than the action of the pressure of the vapors of those or other fractions of oil and water. There will be a complex interaction of the vapors and expanding liquid in the bottom-hole zone. When pyrotechnic charges are used, zonal heating will be observed where, as the distance from the charge is increased, the temperature will fall, and, consequently, a transition of all the components of the well liquid together or separately to a vaporous state will be observed.

The lower the temperature to which the liquid in the bottom-hole chamber 6 is heated, the less the consumption of energy to perform this operation, but the effectiveness of the inflow of oil will be lower. If heating to high temperatures is used (when oils boil), then the temperature near the source of heat will be maximum, i.e., boiling of the heavy and other fractions of oil near the heating source will be observed, and at some distance the temperature will fall and only water and light fractions of oil will boil.

It is most effective to use an explosion for realization of the proposed method for processing the bottom-hole zone (Fig. 4). In this case an increase of the pressure in the bottom-hole chamber 6 is ensured and the liquid therein is heated to the maximum temperatures, i.e. there is simultaneous action of the pressure on the pores in the bottom-hole zone of the productive formation and temperature, reducing the viscosity of the oil. Taking into account that the upper part of the bottom-hole zone of the well 1 is sealed, the effectiveness of the explosion in that case is at least two time more than the effectiveness of the methods for processing the bottom-hole zone of a well which are used at present, since all the combustion products are directed only downwards (a directed explosion takes place).

On the other hand the proposed method for processing a productive formation in the bottom-hole zone of the well 1 includes the simultaneous action of an explosive wave, a hydraulic fracture and temperature, which result in the formation of additional cracks in the bottom-hole zone of the well 1, reduction of the viscosity of oil fractions and especially deposits, and also the reverse flow of liquid from the productive formation to the well 1, which promotes the removal of the deposits from the pores and cracks. In other words, the proposed method for processing the bottom-hole zone of the well 1 provides the positive effects of known methods for processing a bottom-hole zone. Moreover, by sealing the upper part of the well 1, it is more effective than known methods, since direction of the explosion is ensured, and this is at least two times more effective than a simple explosion in the well 1.

Another advantage of the proposed method is the possibility of controlling the degree to which the liquid in the bottom-hole zone is heated, this being dependent on the composition of the oil and the percentage content of light and heavy fractions therein, and also the amount of water, which to a certain degree makes it possible to reduce the power consumed during this operation.

And finally, the proposed method provides for the preservation of geophysical cables and wire, arranged above the bottom-hole zone (above the packer 4).

Greater effectiveness may be achieved if a pressure generator 8 is mounted at some distance from the bottom hole of the well (casing) 1 (Fig. 8). In order to achieve this, a packer 4 is lowered into the well (casing) 1 (Fig. 8), using the suspension means (cable or pipe) 2. The packer 4 is fixed to the wall of the well 1 at some distance from the bottom, forming a bottom-hole chamber 6. Any method for fixing the packer 4 to the wall of the well 1, like any construction of the packer 4, may be used. The pressure generator 8 is secured in the lower part of the packer 4 on a hanger 9 at some distance from the bottom of the well 1 and the end face of the packer 4. The pressure generator 8 may be made in the form of a tank with compressed gas or in the form of a packet of explosive.

Then the column of well liquid is divided by the gas fed from the tank or formed during an explosion of the explosive into two parts, one of which (the lower) is directed toward the bottom-hole zone of the well 1, the other (upper) through the packer 4 - to the above-packer space of the well 1 (Fig. 9). The well liquid directed toward the bottom-hole zone of the well 1 effects hydraulic fracturing in the bottom-hole zone of the well 1, which predetermines expansion of the pores and cracks in the zone of the productive formation surrounding the well 1, and also results in the formation of new cracks. This,

finally, will promote an increase of the filtration of the formation liquid into the well 1, which results in an increase of the inflow of oil.

After the bottom-hole chamber 6 has been cleansed of the well liquid (Fig. 10), the pressure of the gases therein, fed from the tank or formed as a result of an explosion, will fall, i.e. depression of the pressure will occur as a result of reduction of the temperature of the gases (heat through the wall of the well 1 as a result of the thermal conductivity of its walls will pass into the surrounding medium).

The next step is the step of filling the bottom-hole chamber 6 with the formation liquid. Simultaneously with this, movement of the flow of well liquid positioned above the packer 4 into the bottom-hole chamber 6 is closed (Fig. 11). In view of this the pressure of the gases in the bottom-hole chamber 6 will be reduced, i.e. depression of the pressure will occur, and formation liquid will enter the bottom-hole chamber 6. Wherewith, it will wash out the clogging products which are in the pores and cracks. Particles of earth, also to be found in the cracks and pores and hindering filtration of the formation liquid, will also be washed out with the flow of well liquid.

The proposed complex action on the bottom-hole zone of the well 1 (at first hydraulic fracturing, and then the action of pressure depression) enhances the effectiveness of filtration of the formation liquid of the productive formation, which, finally, increases the production rate of oil in the well 1.

In order to realize the proposed method with use of an explosion as a step for the instantaneous increase of the temperature in the bottom-hole chamber 6, it is advisable to use a packer 4 with any construction of the means for radial compaction, but in which the lower end face 5 is made in the form of a concave surface of the second order. In other respects, the packer 4 units may be of any construction. Such a concave surface may be made hemispheric or paraboloidal. These forms of the lower end face 5 of the packer 4 provide for direction of the explosive wave along the longitudinal axis of the well 1 and simultaneously ensure self-compaction of the packer 4 over the surface of the well 1, without creating stress concentrators in the packer 4. In the first case, production of the packer 4 is simplified, in the second - the effectiveness is enhanced, since the lower end face 5 of the packer 4 at the wall of the well 1 has greater length and more gradually passes to cylindrical.

In order to realize the proposed method with the use of an explosion for cleansing the bottom-hole chamber 6 with division of the column of well liquid, which is in this chamber 6, into two parts and their displacement to the productive formation and the

above-packer space of the well 1, it is necessary to use a special construction of the packer, which ensures the passage therethrough of a flow of well liquid from the bottom-hole chamber 6 to the above-packer space of the well 1 and prevents movement of the well liquid in the opposite direction. A packer 4 with a flat lower end face is shown in Figs. 8, 9; with a concave surface of the second order in Figs. 10, 11. Both constructions satisfy the required conditions for passage of the well liquid through the packer 4.

The packer 4 comprises a body 10 (Figs. 8, 9) with a means 11 for radial compaction (a rubber bushing is shown in the Fig., which when heated expands and creates tightness between the body 10 and the wall of the well [casing] 1). The packer 4 is lowered to the required depth by a suspension means 2 (Fig. 8), which may be a cable or pipe. The packer 4 is made with channels (a channel) 12 (Figs. 8-11) which connect its end faces.

The channels 12 may be made parallel to the longitudinal axis of the packer 4 (Figs. 8, 9) or inclined (Figs. 10, 11). A back-pressure valve 13, secured to the body 10 of the packer 4, is mounted in the channels 12 or outside them as shown in Figs. 8-11. The back-pressure valve 13 is shown in the drawings in the form of a flat elastic plate, secured in the central part to the body 10 of the packer 4.

The principle of operation of the packer is as follows.

The packer 4 is lowered to the required depth and by any known method is secured to the walls of the well 1 (Fig. 8). Well liquid is on both sides of the end faces of the packer 4. A pressure generator 8 may be suspended on a hanger 9 from the lower part of the packer 4. A tank with compressed gas or a packet of explosive may be used as the pressure generator 8. The pressure generator 8 may be suspended on a special cable passed through the packer 4. After the explosion (Fig. 9), under the action of the explosion gases formed after the explosion of the explosive or the gas in the tank, the upper part of the column of well liquid in the bottom-hole chamber 6 will be displaced through the channels 12 of the packer 4 into the above-chamber space of the well 1 (Fig. 9). Wherein, the back-pressure valve 13 in the form of an elastic plate. deforming, passes the well liquid into the above-packer space. The lower part of the column of well liquid, which is in the bottom-hole chamber 6, will be pressed toward the productive formation. After the bottom-hole chamber 6 is freed of the well liquid, the temperature of the gases in that chamber 6 will fall as a result of the transmission of heat into the surrounding medium, and this will results in a reduction of the pressure of the gases in the bottom-hole chamber 6 - to depression of the pressure. Under the action of the column of well liquid which is

in the above-packer space of the well 1, the channels 12 of the packer 4 are closed by the elastic force of the material of the elastic plate of the back-pressure valve 13. Reduction of the pressure of the gas will continue in the bottom-hole chamber 6, and after it has fallen below the formation pressure, formation liquid will begin to go from the formation into the bottom-hole zone. The greater the depression of the pressure in the bottom-hole zone, the more intensive will be the inflow of formation liquid into the bottom-hole chamber 6. Wherein, the clogging products and separate particles of earth, clogging the pores and cracks in the bottom-hole zone of the well 1, will be washed out.

It is advisable to use packers 4 in which control of fixation to the walls of the well (casing) 1 is carried out by temperature action. Packers of such a construction are shown in Figs. 12-15.

The packer 4, secured to the suspension means 2 in the form of a cable (Figs. 12, 13) or a pipe (Figs. 14, 15), is installed in a well 1 (Figs. 14-15) or casing 1 (Figs. 12-13). The packer 4 may be of any construction. However, it, in accordance with the technical solution, should be provided with a temperature-action element 14 (this may be either a heating element, for example, an electric spiral, or a cooling element, for example, a thermocouple).

A packer with a structural element made of a material with shape memory is shown in Fig. 14. In this case, a diametral size increase is effected by volumetric expansion of the material of the structural elements (as described above) and by changing the shape of the structural element of the packer 4, made of material with shape memory. Wherewith, the second factor by tens, and sometimes even hundreds, of times exceeds the first.

The packer 4 comprises an elastic cup-type seal 15 with a thrust washer 16, clamps 17, 18 mounted above and below the cup-type seal 15, a cylinder 19 with lobes 20 formed by slots 21, in the lower part of which the slots 21 pass into an opening 22. The cylinder 19 with lobes 20 is made of material with shape memory, and therefore they serve as a drive (when moved apart), and together with the elastic cup-type seal 15 - as sliding cheeks, a part of which closes the gap between the packer 4 and the wall of the well (casing) 1. The cylinder 19 with lobes 20 and slots 21 may be whole or consist of several sectors mounted in a circle. The temperature-action element 14 made in the form of a thermocouple should desirably be mounted near the lobes 20 in order to cool them more effectively. Power to the temperature-action element 14 - thermocouple may be effected from the surface along wires 23. The cylinder 19 is made of a material with shape memory, for example, of a nickel-titanium alloy (for example, titanium nickelide NiTi with

a content of 50% nickel and 50% titanium). The specificity of these alloys is that if a sample made from them is given a certain shape by plastic deformation at a temperature higher than the temperature A_E, and then cooled to a temperature below the temperature M_E and again deformed, destroying the former shape, then after heating the sample to a temperature above the temperature A_B, it will "remember" its original shape. The temperatures M_B and M_E are the beginning and end temperatures of forward martensite conversion, while A_B and A_E are respectively the beginning and end temperatures of reverse martensite conversion. In respect to a titanium nickelide NiTi alloy, the temperatures $M_B = 63°C$, $A_B = 75°C$. Addition of the alloying additions Fe and Co to titanium nickelide NiTi of a stoichiometric composition reduces the temperature at which the shape is restored. The effect of the alloying additions on the shape restoration temperature is set forth, for example, in the work by A.S. Tikhonov, A.P. Gerasimov, I.I. Prokhorov. Use of the shape memory effect in modern mechanical engineering, "Mashinostroenie," Moscow, 1981, p. 80. Different alloys having the shape memory effect have their own physicomechanical parameters. Some of them are presented herebelow: the degree of restoration of the original shape reaches 100%; the degree of reverse deformation reaches 10-20%; the pressure produced during heating reaches 500-700 MPa; the stress necessary for preliminary deformation should not be more than 50-100 MPa. The temperature at which shape memory is manifested in alloys may change from -250° to 500°C, and the width of the temperature interval for restoration of the shape - from 5 to 100°C, hysteresis from 2 to 80°C.

Here material on the base of titanium nickelide NiTi is indicated as an example, this material having high mechanical strength and stability against lengthy temperature cycling, generating significant mechanical stresses when heated, having a significant specific working capacity.

The principle of operation of the packer and the method for fixing it in a well is as follows.

A packer 4 is lowered into a well (or casing) 1 on a suspension means 2 in the form of a cable (Figs. 12, 13) or pipe (Figs. 14-15) to the depth at which it should be fixed. Taking into account that as the depth increases the temperature of the well liquid (this may be drilling mud or a mixture of oil and water) increases, the diametral size of the packer 4 is selected so that at the temperature of the well liquid at the depth of fixation, the diametral size of the packer 4 would be less than the diameter of the well 1. This may be

achieved constructively, that is the parts of the packer 4 made with corresponding diameter, or the packer 4 may be cooled, artificially reducing its diametral size. Then the packer 4 is subjected to temperature action (in this case heating), which results in an increase of its diametral size (Fig. 13). If the packer 4 is made constructively with a diametral size less than the diameter of the well 1, the heating may be carried out with a temperature-action element 14, for example, an electric spiral, or by using a pyrotechnic cartridge (not shown in the drawings). When a pyrotechnic cartridge is used, the heating will be one-time, and then this temperature will be maintained by the temperature of the well liquid. When an electric spiral is used, the packer 4 may be heated a multiple number of times and the maximum or optimum temperature maintained. This is especially important when the temperature of the well liquid is less than the temperature of the martensite conversion of the shape memory alloy used. Wherewith, the heating is carried out from a power source mounted on the surface (not shown in the drawings). As a result of the heating, a tightness is created between the surface of the cup-type seal 15 of the packer 4 and the surface of the wall of the well (casing) 1. In order to remove the packer 4 from the well 1, the temperature load should be reduced (the packer 4 cooled), after which a reduction of the volume of its structural elements occurs, the diametral size of the packer 1 falls, and it may be extracted from the well 1. The cooling may be natural (when the temperature of the well liquid is low) or artificial by using, for example, a thermocouple. In the latter case, the process may be controlled better, since it hardly depends at all on the temperature of the well liquid.

The sequence of these operations is advisable when volumetric expansion of the cup-type seal 15 of the packer 4 is used or it is made of a material with a shape memory in which the temperature of forward martensite conversion is higher than the temperature of the well liquid at the depth of fixation of the packer 4. When executed in this manner, it is necessary to constantly consume power in order to ensure fixation of the packer 4 to the wall of a well (casing) 1.

It is advisable to cool the packer 4 prior to its installation in the well 1 at the required depth (on the surface at the moment when it is to be lowered). Different means may be used on the surface in order to accomplish this (for example, cover the packer with ice), in the well 1 it is most advisable to use a thermocouple for this purpose. While the packer 4 is cooling, its diametral size decreases and it becomes significantly less than the diameter of the well 1, this simplifying the process of lowering the packer 4 into the well 1. Due to the action of the temperature of the well liquid, the packer 4 heats up, which results

in an increase of its diametral size. If the temperature of the well liquid at the depth at which the packer 4 is installed is known, it is possible to calculate the initial diameter so that at the temperature of the well liquid, a tightness will appear between the side surface of the packer 4 and the wall of the well 1. The force which appears during the tightening provides fixation of the packer 4 against the wall of the well 1. In order to remove the packer 4 from the well 1, it is necessary to cool it again (to carry out temperature relief). Wherewith, its diametral size becomes less than the diameter of the well 1, after which it will be possible to extract the packer 4 from the well 1.

The constructions of a packer 4, which is heated, are shown in Figs. 12 and 13, wherewith their fixation to the wall of the well 1 is achieved as a result of the volumetric expansion of the material during heating. Using this principle, a packer 4 of any known construction may be used, providing it with a heating element. In this case the reliability of fixation increases, since, in addition to the mechanical change of the diametral size of the packer 4 (for example, by displacing the tapered surfaces in the packer according to USSR Inventor's Certificate No. 252244), an additional tightness occurs as a result of the volumetric expansion of the material from which the elements of the packer 4 are made.

A packer 4 is shown in Figs. 14 and 15, in which material with shape memory is used. In this case, a diametral size increase is effected as a result of the volumetric expansion of the material (as described above) and a change of the shape of the packer 4.

The lobes 20 prior to being mounted in the packer 4 and after being heated to a temperature exceeding temperature A_E are given the shape shown in Fig. 15, that is the lobes 20 are opened. Then they are cooled and deforming they together form the shape of a cylinder (Fig. 14), i.e. the packer 4 is gathered when the lobes 20 have a flat shape in the longitudinal section, forming together a cylindrical surface. The cylinder 19 together with the lobes 20 is positioned in an elastic cup-type seal 15, wherewith their contact surfaces may be glued. The production of the elastic cup-type seal 15 together with the cylinder 19 and its lobes 20 is possible, wherefore the rubber from which the cup-type seal 15 is made is boiled, the cylinder 19 and lobes 20 will serve as if armature. The problem of producing the elastic cup-type seal 15 together with the cylinder 19 and its lobes 20 is solved concretely during the selection of the materials (what is meant is the temperature to which the rubber of the cup-type seal 15 is heated and the temperature A_B). An opening 22 is made in the cylinder 19 to eliminate the formation of cracks in the whole part of the cylinder 19. The cylinder 19 with lobes 20 and the cup-type seal 15 serve as the sliding cheeks.

Prior to the packer 4 being lowered, power is fed into the well 1 along wires 23 to the temperature-action element 14 in the form of a thermocouple serving as a cooler. The latter lowers the temperature of the structural elements of the packer 4, and therefore its diametral dimensions are somewhat reduced, while the lobes 20 retain a cylindrical shape (Fig. 14). The packer 4 is lowered into the well 1 to the required depth. Then the power to the thermocouple is turned off. The structural elements of the packer 4 are heated under the effect of the temperature of the well liquid. When the temperature rises above A_B, the lobes 20 take on the shape shown in Fig. 15, which will be maintained as long as the temperature will have an effect. If a more rapid rise of the temperature is necessary, the packer 4 may be additionally provided with a pyrotechnic cartridge or electric spiral, which may be placed between the suspension means (pipe) 2 and the cup-type seal 15 (not shown in the Fig.). The use of an additional supply of heat, for example, the heat of an electric spiral, is justified in the case where the temperature of the well liquid is below the temperature A_E, which occurs when the wells are not deep and in the case of use of material with shape memory, which has the values A_B, A_E, M_B and M_E greater than the temperature of the well liquid. This, in turn, is advisable when universal packers 4 are used which operate at all depths, wherewith at large depths, the temperature of the well liquid is sufficient for fixation, and when used at small depths - an additional supply of heat is necessary.

The open lobes 20 (Fig. 15) press the cup-type seal 15 against the surface of the wall of the well 1. Volumetric expansion of the structural elements of the packer 4 as a result of the temperature will promote tightness between the surfaces of the elastic cup-type seal 15 and the wall of the well 1.

In order to extract the packer 4 from the well 1, it is necessary to cool the lobes 20, feeding power to the thermocouple and providing temperature relief to the packer 4. The lobes 20 converge in a radial direction, the tightness between the surfaces of the elastic cup-type seal 15 and the wall of the well 1 disappears, after which the packer 4 may be extracted from the well 1, since its diametral size will be small, less than the diametral size of the well 1.

The described operations, inherent to the method for fixing the packer 4 to the wall of a well (casing) 1, in particular - temperature action on the packer 4, do not depend on its construction. Existing packers 4 may be used, providing them with temperature-action elements 14 (heaters and coolers of different principles of operation). In that case the reliability of their fixation is enhanced. It is advisable to use packers 4, the principle of

action of which is based only on the action of temperature. In that case a greater effect will be achieved, in particular: the construction is simplified; the reliability of operation is enhanced; control of the process of fixation is significantly simplified, since it is provided by a special signal sent from the surface, which does not depend on the pressure of the well liquid, the packer 4 may be fixed at any depth and its extraction from the well 1 is ensured.

Industrial Applicability

The proposed technical solution may be used most effectively in the oil production industry: in order to increase the productivity of a well 1 by intensifying the flows of oil; to increase the oil recovery factor; during repair of wells; to cut off water-encroached formations, etc. The method for processing the productive formation in a bottom-hole zone of a well, in accordance with the technical solution, is highly effective, relatively simple and convenient in use, since it is a single-step method. The packer 4 for realization of the proposed method is simple in production, ensures high reliability of fixation at any depth of the well 1 and at different distances from its bottom hole. As compared with known method for processing the productive formation it is at least two times more effective because the used explosion (heating) energy is directed to the bottom hole of the well 1, while in known methods more than 50% of the energy of an explosion goes upwards and does not act on the productive formation. The construction of the packer and the method for fixing it provide convenience of control due to the use of a special signal consisting of heating and cooling packer elements to temperatures which are not present near the packer 4 in the well liquid at the necessary depth of its fixation.

CLAIMS

1. A method for processing a productive formation in a bottom-hole zone of a well (1), comprising heating liquid in the bottom-hole zone and removing clogging products from the bottom-hole zone, characterized in that a temperature-action element (14) for heating the liquid to a temperature above the boiling point of its components is lowered into the bottom-hole zone with use of a suspension means (2), a bottom-hole chamber (6) is formed in the bottom-hole zone of the well (1), an upper portion of the chamber higher than the positioning of the temperature-action element (14) is sealed by a packer (4), after being heated the liquid is cooled, wherein heating the liquid and cooling it is carried out within the volume of the bottom-hole chamber (6), then the bottom-hole chamber (6) is unsealed by removal of the packer (4), after which the clogging products together with oil products are removed from the bottom-hole zone.

2. A method according to claim 1, characterized in that the liquid in the bottom-hole chamber (6) is heated to a temperature above the boiling point of one of the light oil fractions, e.g., gasoline.

3. A method according to claim 1, characterized in that the liquid in the bottom-hole chamber (6) is heated to a temperature above the boiling point of water.

4. A method according to claim 1, characterized in that the liquid in the bottom-hole chamber (6) is heated to a temperature above the boiling point of one of the heavy oil fractions, e.g., oils.

5. A method according to any one of claims 1-4, characterized in that the liquid in the bottom-hole chamber (6) is heated instantly, e.g., by an explosion.

6. A method according to any one of claims 1-5, characterized in that cooling the liquid within the volume of the bottom-hole chamber (6) is carried out in a forced manner with the use of, for example, thermocouples.

7. A method according to any one of claims 1-5, characterized in that cooling the liquid within the volume of the bottom-hole chamber (6) is carried out in a forced manner, feeding cold water from the surface.

8. A method according to any one of claims 1-7, characterized in that a column of well liquid in the bottom-hole chamber (6) is divided into two parts by the packer (4) with at least one channel (12) connecting its end faces and with a back-pressure valve (13), wherein one of the parts of the column of well liquid is directed toward the bottom-hole zone of the well (1) for hydraulic fracturing, the other part is removed through the channel

(12) of the packer (4), and movement of the well liquid through that channel (12) toward the bottom-hole chamber (6) from the above-packer space of the well is closed.

9. A method according to claim 8, characterized in that after removal of a part of the column of well liquid from the bottom-hole chamber (6) through the packer (4), the pressure in the upper part thereof is reduced and simultaneously the bottom-hole chamber (6) is filled with formation liquid.

10. A packer (4) for processing a productive formation in a bottom-hole zone of a well (1), comprising a body (10) with a means for radial compaction in the form of sliding cheeks, a cup-type seal (15) and a drive, and a suspension means (2), characterized in that its lower end face (5) is made in the form of a concave surface of the second order.

11. A packer (4) according to claim 10, characterized in that the concave surface of the second order is made hemispherical.

12. A packer (4) according to claim 10, characterized in that the concave surface of the second order is made paraboloidal.

13. A packer (4) according to any one of claims 10-12, characterized in that in the case where a pressure generator (8) is used in the well (1), including with an explosive, the packer (4) has at least one channel (12) connecting its end faces, and a back-pressure valve (13) is mounted with the possibility for passage of a flow of well liquid from a bottom-hole chamber (6) through the channel (12) of the packer (4) into above-packer space due to the action of pressure generator (8) gases, and for elimination of movement of the well liquid from the above-packer space into the bottom-hole chamber (6) with closure of the channel (12) under the action of a column of liquid in the above-packer space and depression in the bottom-hole chamber (6).

14. A packer (4) according to claim 13, characterized in that a back-pressure valve (13) is mounted in its channel (12).

15. A packer (4) according to claim 14, characterized in that the channel (12) connecting its end faces is made in the body of the packer (4), and the back-pressure valve (13) is mounted from the side of its upper end face.

16. A packer (4) according to any one of claims 10-15, characterized in that its sliding cheeks are made in the form of a cylinder (19) with longitudinal slots (21), ending with openings (27), wherein longitudinal parts of the cylinder (19) between the slots (21) are made in the form of lobes (20) of a material with shape memory.

17. A packer (4) according to claim 16, characterized in that it has a temperature-action element (14) in the form of a cooler to reduce the temperature of packer (4) elements when electric power is applied to the cooler.

18. A packer (4) according to claim 17, characterized in that it is additionally provided with a heater, for example, a pyrotechnic cartridge or an electric spiral.

19. A method for fixing a packer (4) in a well (1), comprising lowering the packer (4) into the well (1) to a required depth, increasing diametral size of the packer (4) by changing the shape of sliding cheeks during reverse martensite conversion of material with shape memory, deforming its cup-type seal (15) in a radial direction, subjecting the packer (4) to temperature action, different from the temperature of the well liquid at the point of its installation, characterized in that the temperature action on the packer (4) is carried out by reducing the temperature to a temperature below the temperature of the well liquid at the point of installation of the packer (4) prior to lowering the packer (4) to the required depth.

20. A method according to claim 19, characterized in that temperature relief of the packer (4) is carried out after temperature action on the packer (4) at the point of its installation in the well (1) at the required depth.

INTERNATIONAL SEARCH REPORT

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PCT/RU 00/00402

A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7: E21B 43/24-43/263, 33/12-33/16, 23/00, 23/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	RU 2132943 C1 (000 "SIBRES")10 July 1999 (10.07.99), the claims	1-8
Y	SU1691515 A1 (VSESOJUZNY NAUCHNO-ISSLEDOVATELSKY I PROETKNY INSTITUT GEOTREMII PROIZVODSTVENNDGO OBIIEDNENIYA "SOJUZBURGAZ"), 15 November 1991 (15.11.91), the whole document	1-8
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☒ Further documents are listed in the continuation of box C. ☐ Patent family members are listed in annex.

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"&" document member of the same patent family

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C. (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	the abstract, page 14 of the description	13, 15, 17, 21
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